

# **CASE STUDY: HYBRID 4WD VEHICLE (H4V)**



## **Project highlights**

- ◆ Plug-in hybrid with removable battery cassette - allows exchange for charged units or charging away from vehicle
- ◆ Retro-fitted to existing vehicle – technology can be added to current product range
- ◆ MIRA e-differential control system, for efficient power management and improved driveability
- ◆ Regenerative braking, to capture energy otherwise lost through braking
- ◆ Nanophosphate™ high power lithium ion batteries providing improved power, safety and range
- ◆ Gearbox oil heating for reduced frictional losses
- ◆ New twist beam design incorporates rear drive shafts facilitating 4WD
- ◆ Improved aerodynamics package – reduces fuel consumption under realistic driving conditions
- ◆ CO<sub>2</sub> rating of 104 g/Km
- ◆ 64mpg equivalent fuel economy – a 30% improvement over donor vehicle

# CASE STUDY:

## HYBRID 4WD VEHICLE (H4V)

### Background

Electric drives are clean, offering zero –emissions (at the vehicle). They have excellent low-speed/high torque characteristics, are quiet and use a low cost energy source. However current battery technology means electric vehicles suffer from poor range even in low power vehicles limited to lower driving speeds.

Internal combustion engines, though far cleaner than in the past, still produce undesirable tailpipe emissions, and consume more expensive fuels.

Hybridisation, combining both electric and ICE powertrains, can take the best aspects of each delivering a practical vehicle with improved fuel economy and reduced emissions. MIRA's approach to hybridisation adds the further benefits of optional 4-wheel drive for improved driveability or electric only modes for zero-emissions and low running costs.

### Technology

The H4V vehicle can be described as a Series / Parallel, Petrol / Electric Hybrid with a High Efficiency Petrol Engine driving the front axle and a Battery / 2 Motor combination driving the rear axle. In addition the vehicle has removable lithium ion battery pack cassettes for off-board recharging. It is a charge sustaining hybrid with plug-in hybrid functionality without connecting the vehicle directly to the mains electricity supply.

Turning the ignition key does not start the ICE but puts the electric motors on standby. The driver then selects the appropriate gear (F-N-R) and presses the accelerator pedal to move off quietly in electric vehicle (EV) mode.

Unless the batteries are severely depleted the engine remains off until the car is outside of the urban environment, i.e. above 35mph. The engine then starts automatically and runs in a “series” mode, gently charging the main traction batteries and warming the catalyst up to ensure low levels of pollution are maintained.

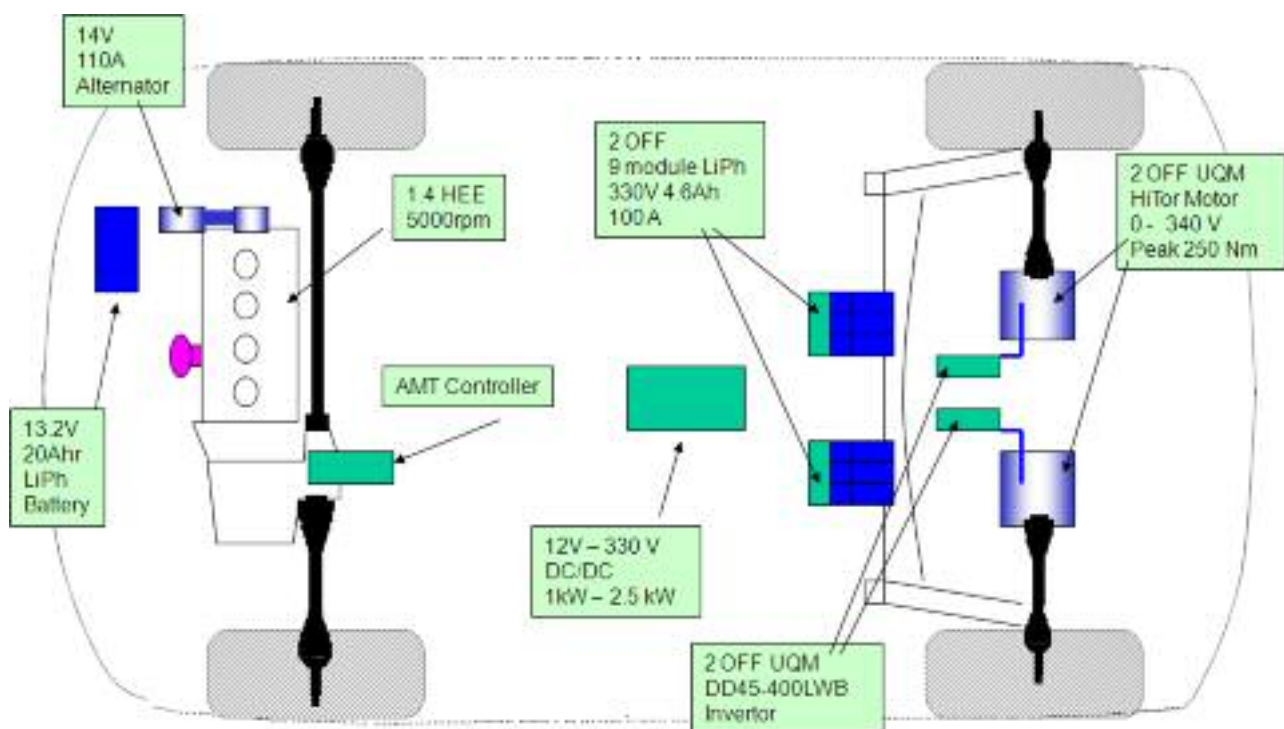
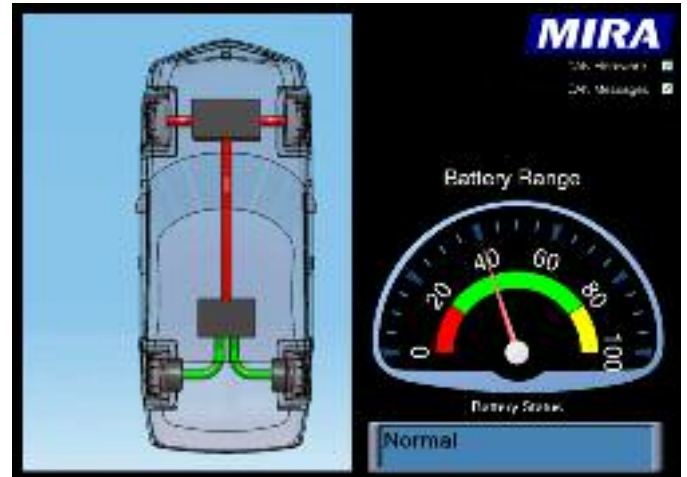


Figure 1 H4V Schematic Layout

Above 40mph the vehicle control system (VCS) matches the ICE speed to the road speed needed for the automated manual transmission (AMT) to be able to engage the required gear. Power is now fed from both the ICE and the electric motors to drive the car, creating a parallel hybrid mode.

Once the vehicle has reached the desired speed, less power is required and the VCS gradually converts the motors into generators to recharge the batteries. The ICE continues to provide the power to drive the vehicle forward and to drive the electric motors as generators. When the driver removes his foot from the accelerator pedal the motors continue to regenerate, thereby slowing the vehicle.

The ICE will remain on for a minimum time, either engaged or idling, to ensure the catalyst remains hot enough to remove any pollutants made by the engine during start-up.



Additional display showing power distribution and range.

Although the control strategy attempts to recharge the batteries whenever it can, the actual rate of recharge is dependant on the driving style and the journey. The H4V is classified as a “plug-in-hybrid” allowing the batteries to be charged from the mains, but it also overturns the concept of wires running across the pavement to on-street parked car. The batteries are housed in removable cassettes, easily removed for charging in the home or exchanged with other units available at the road side.

## Engine Recalibration

In order to integrate the MIRA hybrid system it was necessary to replace the donor vehicle's engine control unit (ECU) with a new open-architecture ECU in order to:

- ◆ Enable 'fly by wire' engine control over CAN for the H4V VCU (Vehicle Control Unit)
- ◆ To reduce the engine base fuel consumption
- ◆ To shift the minimum BSFC (Brake Specific Fuel Consumption) to a lower speed i.e. the high torque region

To achieve this MIRA's powertrain engineers used modelling and analysis tools to determine the required control strategies. However as the OE engine ECU is 'closed' i.e. the source code is proprietary, it was necessary to migrate the controller strategy to an 'open' architecture. Once this was done they were able to fully integrate the modified powertrain into the H4V car.

## Benefits of the Technology

As many commuters live less than 5 miles from their workplace it is possible to travel to and from work without ever using the ICE and recharging the 2 battery packs each evening. With electricity much cheaper than petrol or diesel, and potentially made from carbon neutral sources, the driver could benefit from both lower costs and lower carbon emissions.

Even if the car was to be used for longer distances or higher speeds the engine has been optimised by MIRA to consume fuel as efficiently as possible, producing extremely low levels of all regulated pollutants.

MIRA's experts improved both the car's aerodynamics and its rolling resistance, reducing the car's need for excessive power at higher speeds.

The donor vehicle, a Skoda Fabia, was chosen to highlight the modularity of the vehicle conversion, demonstrating that many existing cars could benefit from some or all of these technological benefits.

MIRA has extensive experience in electric and hybrid vehicle design and development. H4V is just one of the many innovative electric and hybrid vehicles developed by or in conjunction with MIRA. Others include:

#### ASTI (Accessible Transport Integration) electric bus



The ASTI project demonstrated practical approaches to reducing the environmental effects of local accessible bus transport.

#### Porter electric van



A practical electric-powered van, Porter offers a low maintenance zero emissions solution popular with local government.

#### MIRA's MG-TF HPD



MIRA's high performance hybrid sports car introduced the concept that hybrids can deliver environmental benefits in addition to an exhilarating drive.

#### Project Choice hybrid bus



The Project Choice bus combined an innovative hybrid powertrain with GPS and intelligent route planning.

#### Tesla Motors – high performance electric sports car



MIRA helped Tesla Motors develop several key attributes of their impressive green sports car.

#### MACE Hybrid Autonomous Vehicle



A diesel-electric hybrid powertrain gave MIRA's autonomous defence vehicle an extended range and invaluable stealth mode.

#### For further information contact:

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